Mortalities—1961

v. of Sask., Regina

In about an hour and a half, with all members of the family assisting, 94 birds of 22 species were picked up in the vicinity of the tower (see table 1). Of the 22 species, 13 different kinds of warblers and three kinds of vireos were represented. Red-eyed Vireos made up 51 per cent of the total. There were 18 males and 24 females; 12 of the males and 14 of the females were immatures (as indicated by skull ossification), yielding a ratio of 38 per cent adult to 62 per cent immature. These figures indicate a fairly well-balanced population with possibly fewer adult males than normal, suggesting that some males in the population may have migrated earlier. At any rate, it seems that all members of the migrating population were equally affected by the mortality at the tower and that the total species sample was random. The preponderance of immatures in the sample (55 per cent) is of interest in view of the observations of Brewer and Ellis (1958) that adults predominate in fall kills.

Kemper (1958), in discussing a kill of 1525 birds involving 82 Red-eyed Vireos and 25 Philadelphia Vireos, notes the absence of the Warbling Vireo in his sample and raises the question of whether some species are less prone to accidents. It is curious

1

ver, September 3, 1961

Number	Age and Sex
4	3 imm., 1 ad.
1	imm
2	2 imm
48	26 imm., 18 ad
1	?
3	3 ad
2	1 imm., 1 ad
10	2 imm., 8 ad
1	imm., male
1	1 imm., male
3	3 imm
4	4 imm
3	1 ad., ?
1	1 imm., female?
1	imm., female
1	1 ad., male
1	ad., female
1	ad., male
1	ad.
2	2 ad
2	1 ad., 1?
1	1 ad., male
94	

that although one of the three night-roosting birds which I captured by hand in the evening of September 2 was a Warbling Vireo, none was found at the tower. In a later report on other kills, Kemper (1959) notes that wood warblers and vireos "are the hardest hit." The present data certainly support this point.

It is of considerable interest to note the presence of five species on the list which have been considered "rare" (Solitary Vireo, Mourning Warbler) or "very rare" (Philadelphia Vireo, Connecticut Warbler, Bay-breasted Warbler) in the Regina district (Belcher, 1961). The number of Bay-breasted Warblers (nine per cent of the total of warblers) suggests that a revision of the status of this species as well as others may be necessary for the Regina area. No doubt the difficulty of identification of species has helped to account for the scarcity of Regina records. However, regional rarities have been recovered from other TV tower mortalities, e.g., Kemper (1958:6) states: "Almost astonishing is the large number of 64 Connecticut Warblers. These had always been considered among the rarest of transient warblers; I have practically no previous substantial sight records of these in five years." One species recorded at the TV tower, MacGillivray's Warbler, may now be added to the Birds of Regina list (Belcher, 1961); sight records of this species (backed by detailed notes) had previously been made by Frank Brazier at Regina on May 28, 1960 (male), August 25, 1960 (sex not determined), and August 20, 1961 (male). These birds were observed by Brazier in shrubbery near the Museum and in the Legislative Grounds (pers. commun., Sept. 3, 1961). MacGillivray's Warbler is the western counterpart of the Mourning Warbler (see Peterson, 1961), breeding in Saskatchewan in the Cypress Hills where it is regarded as "common" by Godfrey (1950). The specimens of the MacGillivray's Warbler, Connecticut Warbler and a Bay-Breasted Warbler were preserved, although they were in poor condition, stripping and badly chewed by crickets.

Apparently a majority of the birds were killed sometime during the morning of September 2 when it was raining.

CKCK-TV employee, Harvey Gay, stated upon query that when he arrived at the station about 8:30 that morning he noticed a few birds lying dead on the parking lot and one live but dazed bird which he removed from the path of vehicles. Upon coming out at noon, however, he noticed that there were far more birds in sight. Mrs. Jean Harrison, another employee, said that when she arrived the same morning she hadn't noticed any birds, but she pointed out that she had been in a hurry to avoid the rain which was falling at that time. She, too, was impressed by the number of birds in sight when she came out at noon.

These observations were supported by our own observations of the following day: a few of the dead birds which we picked up on September 3 were stuck to the ground and had mud in their feathers; one bird even had large clods of mud on its toes. Several had been found beneath shrubbery, in a manner suggesting that they had, as crippled birds, attempted to seek shelter. The weather on the morning of September 2 was especially unfavorable for small birds. The Regina weather station reported for that day a massive cold front which moved from north to south with low temperatures, rain and wind at Regina. A light rain fell from 3:30 a.m. to 10:30 a.m.; the temperature dropped from 59 degrees at 2:00 a.m. to 36 degrees at noon. The wind, which had been S-SE at 15 mph, shifted suddenly to N at 39 mph, gusting to 40 mph, at 3:30 a.m., with a resultant wind-chill of about 0 degrees. The temperature rose gradually after noon, then dropped again to 36 degrees overnight and the wind continued overnight. Throughout the morning it had been very cloudy with a ceiling of 800 feet. About 10:00 a.m. on that day I had noticed an abundance of small birds about my home, where there are not usually many, and was especially struck by the sight of a Least Flycatcher sitting on bare ground as if very tired. If the birds were mainly killed in the early morning, and daytime collision of birds at a tower has been reported by Kemper (1959), it may be supposed that they flew into the TV tower and its guy wires while partly blinded by the rain and swept by the wind. These migrants may have been attempting to land during

ıe storm, seeking haven in the ushes and rows of trees which are ıcated on the station grounds, and ·hich stand out in an otherwise tree-ss plain. On September 3, while we ·ere looking for dead birds, we oticed an abundance of live vireos, arblers and sparrows in this shrub-ery. All of the birds which we pick-d up were found within 500 feet of ıe tower, mainly within 300 feet, ·ith a predominant number being ound in the southeast quadrant of ıe area surrounding the tower and ver a dozen on the roof of the sta-on. This suggests that many were illed while flying at very low alti-ude. Brewer and Ellis (1958) have bserved an association between ıortalities and the arrival of a cold ·ont, due either to a front damming ack and building up concentrations f birds or preventing a flow of air iding movement. No doubt the con-entration of birds in the Regina area ·as brought about by the advancing old front; the low cloud cover on the ıorning of the second of September, ıe low temperature and the wind eneity all combined to produce a tuation perilous to small birds. Such combination appears to be rare in us vicinity. Jack Unger, grounds uperintendent at CKCK, stated that e had never before seen so many ırds killed at the tower.

On September 10, 1961, impressed y the number of migrants in the egina area Don and Dot Wade, rank Brazier and I decided to check ıe tower again. We arrived at 9:30 m. and were immediately aware iat a kill had occurred for dead ırds were again lying on the drive-ay and parking lot. The four of us, ı about an hour and a half, picked) 113 birds comprising 21 species ıee table 2). Since Elmer Fox and rank Brazier had checked the tower ı the previous day (Saturday, Sep-mber 9), it was clear that the mor-lity had occurred overnight or in ıe early morning. In contrast to the ll of the previous week there seem-l to be little association with weath-er data. The wind on Saturday ·ening varied from 15 to 20 mph,) to 12 mph overnight and 17 mph ınday morning with a direction of in the evening and N-NE in the ·orning. Overnight it was overcast ith alto-cumulus clouds at 12,000 13,000 feet. Two cold fronts, how-·er, moved through the area, one at 6:00 a.m. on Saturday, the second, before noon on Saturday; thereafter the temperature gradually fell from 71 degrees to 53 degrees at midnight.

Eight species additional to those found on September 3 were recovered (those species of table 2 listed with scientific names), but 10 species found on September 3 were not recorded in this casualty list. Again, a few species recorded as rare at Regina (Belcher, 1961) were recovered, notably Bay-breasted Warbler and Le Conte's Sparrow. Because nearly all of the birds were in perfect condition an assortment of specimens was submitted to the Saskatchewan Museum of Natural History, hence data on sex and age has not been tabulated for this series. However, in some cases significant data are available. The adult-immature ratio was nearly equal: of 76 birds that were checked, 36 were adults and 40 were immatures. Some species showed disproportionate ratios, for example, 10 out of 11 Blackpoll Warblers that were checked were immatures (four out of four on September 3). On the other hand, only one out of 15 Yellow Warblers was an immature (two out of 10 on September 3). These data suggest a differential migration in these species. Sex ratios, so far as this information is available, were normal, e.g., seven adult male to seven adult female Yellow Warblers, but the Ovenbird showed a surprisingly high proportion males, only one adult being f the sample together with si and six immature females.

Most of the birds were found southwest quadrant of a circ tering on the tower. Twent were found on the roof of t tion, 79 were found in the a rectly west and south of the ing, mainly within about 3(The entire north half of th yielded only five birds. This d tion is probably the result of ing birds being blown some d in the direction of the wind. T with the wind direction for th of the kill (N and N-NE). It presumed that these migran been flying in a southerly di but this was not established surprising that so many were close to the base of the to birds were actually striking per end of the tower one woul pose that many of them wo carried by the wind for a c able distance. Perhaps, as su for the first kill, most colli curred at rather low levels.

The total number of spe these two mortalities (Septe and 10) is 30 (see table 3). W comprise 50 per cent of all cies; the 15 kinds which were represent more than half of t biers known to have occurred gina (Belcher, 1961). Note a warblers comprised 34 per c the total numbers found on S ber 3, and a surprising 71 p of the total on September 10.

Late in the afternoon of Sep 10 I had an opportunity to brief check at the TV tower at out found only one Red-eyed and two Savannah Sparrows, ently killed the night before.

The evening and night of Se ber 18 seemed particularly ous to small birds, a cold w ng in from the northwest strong winds and a dense and smoke from forest fires. ngly, on September 19, at 8 I checked at the Regina Stadi found the following birds which clearly overnight kills:

Pintail, *Anas acuta*
Green-winged Teal, *Anas carolinensis*
Sora
American Coot, *Fulica americana*
Harris' Sparrow, *Zonotrichia querula*

TABLE 2

Birds recovered at TV tower, September 10, 1961

Species	Number
Common Snipe, *Capella gallinago*	1
House Wren, *Troglodytes aedon*	1
Swainson's Thrush, *Hylocichla ustulata*	9
Gray-cheeked Thrush, *Hylocichla minima*	4
Red-eyed Vireo	2
Black-and-White Warbler	5
Tennessee Warbler	10
Orange-crowned Warbler, *Vermivora celata*	5
Yellow Warbler	18
Magnolia Warbler	7
Bay-breasted Warbler	2
Blackpoll Warbler	13
Palm Warbler, *Dendroica palmarum*	4
Ovenbird	14
Yellowthroat	1
American Redstart	2
Savannah Sparrow	3
Le Conte's Sparrow, *Passerherbulus caudacutus*	1
Vesper Sparrow, *Pooecetes gramineus*	1
Lincoln's Sparrow	3
TOTAL	113

...Saturday, the second, ... on Saturday; thereafter ...erature gradually fell from ...s to 53 degrees at midnight.

...species additional to those ...n September 3 were recover... species of table 2 listed ...entific names), but 10 species ...n September 3 were not re... in this casualty list. Again, a ...ies recorded as rare at Re...lcher, 1961) were recovered, Bay-breasted Warbler and ...'s Sparrow. Because nearly ...e birds were in perfect condi... assortment of specimens was ...d to the Saskatchewan ... of Natural History, hence sex and age has not been ...d for this series. However, ... cases significant data are ... The adult-immature ratio ...irly equal: of 76 birds that ...ecked, 36 were adults and ... immatures. Some species ...disproportionate ratios, for ... 10 out of 11 Blackpoll War... it were checked were immature out of four on September ...he other hand only one out ...ellow Warblers was an im... two out of 10 on September ...e data suggest a differential ...n in these species. Sex ratios, ...s this information is avail... were normal, i.e., seven adult ... seven adult female Yellow ...s, but the Ovenbird showed a surprisingly high proportion of females, only one adult being found in the sample together with six adult and six immature females.

Most of the birds were found in the southwest quadrant of a circle centering on the tower. Twenty-eight were found on the roof of the station, 79 were found in the area directly west and south of the building, mainly within about 300 feet. The entire north half of the area yielded only five birds. This distribution is probably the result of colliding birds being blown some distance in the direction of the wind. This fits with the wind direction for the night of the kill (N and N-NE). It may be presumed that these migrants had been flying in a southerly direction, but this was not established. It is surprising that so many were found close to the base of the tower. If birds were actually striking the upper end of the tower one would suppose that many of them would be carried by the wind for a considerable distance. Perhaps, as suggested for the first kill, most collisions occurred at rather low levels.

The total number of species in these two mortalities (September 3 and 10) is 30 (see table 3). Warblers comprise 50 per cent of all the species, the 15 kinds which were found represent more than half of the warblers known to have occurred at Regina (Belcher, 1961). Note also that warblers comprised 34 per cent of the total numbers found on September 3, and a surprising 72 per cent of the total on September 10.

Late in the afternoon of September 10 I had an opportunity to make a brief check at the TV tower at Caron, but found only one Red-eyed Vireo and two Savannah Sparrows apparently killed the night before.

The evening and night of September 18 seemed particularly hazardous to small birds as a cold wave passing in from the northwest brought strong winds and a dense fog of mist and smoke from forest fires. Accordingly, on September 19 at 8:30 a.m. I checked at the Regina station and found the following birds which were clearly overnight kills:

Pintail	*Anas acuta*	1 um
Green-winged Teal	*Anas carolinensis*	1 um
Sora		1 im
American Coot	*Fulica americana*	1 Ad
Harris' Sparrow	*Zonotrichia querula*	1 im

Harris' Sparrows were quite common in the shrubbery at the station; since this was the first record of the species for the season it had clearly moved in overnight. In view of the weather conditions this seemed an unusually small kill and this suggests that weather alone is not sufficient to account for large casualties. Probably, the presence of large numbers of birds is an even more important factor.

Such seemed to be the case at Melfort where a large number of birds were reported killed, apparently on the same abominable night. A newspaper account on September 20 stated that 147 birds had been picked up in Melfort "apparently killed in flying against business buildings in the town, possibly because of the heavy smoke pall overlying the town." George T. Anderson, principal of the Melfort Collegiate, at my request kindly sent me a few specimens which had escaped the disposal system. These were Yellow-bellied Sapsucker (*Sphyrapicus varius*) Swainson's Thrush, Connecticut Warbler, Myrtle Warbler and Yellowthroat. The latter two were picked up on the morning of September 12, apparently the victims of large windows, and these species were thought by Mr. Anderson to represent the more common species in the kill.

No doubt casualties are occurring at other towers. Jack Livingston, Executive Director of the Canadian Audubon Society, George Ledingham, Doug Stephen, Canadian Wildlife Service, and I had occasion to check on September 24 the 455 foot tower of the CBK radio transmitting station

TABLE 2

recovered at TV tower, September 10, 1961

	Number
...nipe *Capella gallinago*	1
...n *Troglodytes aedon*	1
Thrush, *Hylocichla ustulata*	9
...ed Thrush, *Hylocichla minima*	4
Vireo	2
Alive Warbler	5
Warbler	10
...wood Warbler *Vermivora celata*	5
...rbler	18
...rbler	7
...d Warbler	2
Warbler	13
...ler, *Dendroica palmarum*	4
	14
...t	1
Redstart	2
Sparrow	3
Sparrow, *Passerherbulus*	
...row *Passerella iliaca*	1
...row *Passerites graminous*	1
Sparrow	3
	113

TABLE 3

Combined list of species

Sora*	Bay-breasted Warbler**
Common Snipe	Blackpoll Warbler**
Least Flycatcher*	Palm Warbler
House Wren	Ovenbird**
Swainson's Thrush	Connecticut Warbler*
Gray-cheeked Thrush	Mourning Warbler*
Solitary Vireo*	MacGillivray's Warbler*
Red-eyed Vireo**	Yellowthroat**
Philadelphia Vireo*	American Redstart**
Black-and-White Warbler**	Savannah Sparrow**
Tennessee Warbler**	Le Conte's Sparrow
Orange-crowned Warbler	Vesper Sparrow
Yellow Warbler**	Clay-colored Sparrow*
Magnolia Warbler*	Lincoln's Sparrow**
Myrtle Warbler**	Chestnut-collared Longspur*

Single asterisk—Sept. 3; no asterisk—Sept. 10; double asterisk—Sept. 3 and 10.

Watrous. An old carcass of an Eared Grebe (*Podiceps caspicus*) and a recent Swamp Sparrow (*Melospiza georgiana*) were found. Station personnel informed us that in the past they had occasionally noticed dead birds under the tower. Bird watchers ought to be alert to the possibilities of fatalities at this and other towers and structures, especially during the fall and spring migration. Information obtained in this way, in addition to providing distribution records and specimens, may assist in further understanding the basis for these mortalities and thus in finding ways to help reduce this annual loss of songbirds.

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AMERICAN GOLDEN PLOVER IN FALL MIGRATION AT HORSESHOE LAKE

On September 17, 1961, I observed a flock of 17 American Golden Plover at Horseshoe Lake northwest of Yorkton. They were studied in detail while at rest and flushed twice to note flight markings. At rest they appeared generally brown above, three individuals having a distinct golden tinge to their upper parts. In flight, the lack of conspicuous markings was evident—there were no wing bars, rump and tail were evenly dark, and there were no black axillars as in the Black-bellied Plover.

Checking Stuart Houston's list of "The birds of the Yorkton district" (1949. Can. Field-Nat. 63: 215-241) and recent issues of the **Blue Jay**, I could find no record of this species in fall migration. However, Audubon Field Notes lists numerous observations for interior regions within the last few years, the nearest being in South Dakota in the autumn of 1958 and 1960. In the general summary of the 1958 autumn migration reference is made to the continually increasing number of observations which indicate that more individuals are deserting their traditional ocean migration routes in favour of partial or complete overland flights.—**William Anaka**, Spirit Lake.

EDITOR'S NOTE: It is always difficult to assess how much migration patterns are actually changing, since a lack of good observers and good records may partly explain the apparent absence of a species. It is interesting to note, as a matter of comparison, that the American Golden Plover was once considered unknown in the Regina area in fall migration, although Margaret Belcher's *Birds of Regina* (1961) gives fall records as far as early as 1913. We know of several observations of the Golden Plover again this fall in the Regina area—a group of 2[illegible] was seen October 8 by Frank Brazier and R. W. N[illegible] and a group of five, with one Black-bellied Plover, on October 21 by M. Belcher and L. Murray.

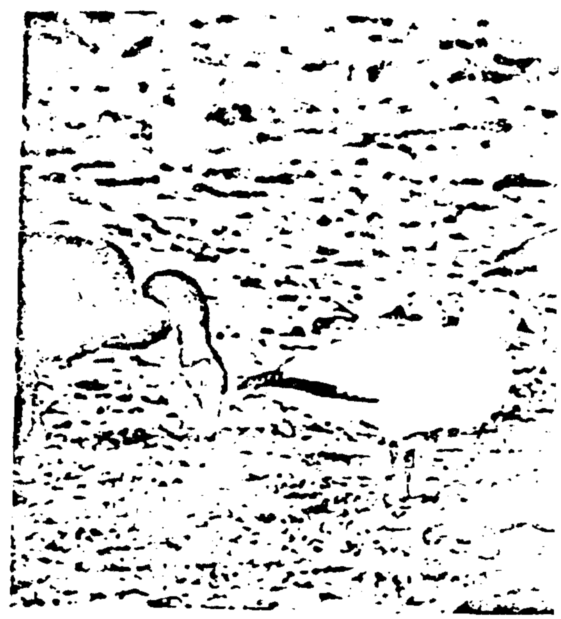
(Continued from page 156)

he is willing to pay. Planning for lure crop planting must go ahead. If Crown land is not available in sufficient quantity to meet the need, suitable private land adjoining the present sanctuary must be acquired. The farming operations required to produce the lure crop could be carried out by local farmers after bids have been submitted on various contracts. These are some of the obstacles that will have to be overcome to alleviate the local crop depredation problem. Perhaps some solution to the problem may be forthcoming through the Agricultural Rehabilitation and Development Act.

(Continued from page 157)

counted ten birds but one got out in the next few minutes. Another got tangled in the net and drowned. I got mired in the mud trying to untangle one bird and fell over with a Sandhill Crane in my arms, saying "I love you, Honey, and some day you will be in a beautiful zoo admired by thousands of children."

I got six Sandhills for the zoo and Dr. Millar banded the two remaining birds. This adventure was almost as exciting as the time I lassoed a live buffalo in Brandon Park and transferred it to Moose Jaw Wild Animal Park for Mr. Paynter, Director of Wildlife.



Ross' Goose at Wascana Lake, Regina

ROSS' GEESE AT LAST MOUNTAIN LAKE

I was fortunate enough this year to be employed by the Canadian Wildlife Service on their Sandhill Crane study at the north end of Last Mountain Lake during part of August and September. On September 13 when Dr. J. B. Millar of the C.W.S. and I were driving down the central point which projects two miles south into the north end of the lake (about nine miles west of Hatfield) we noticed some white geese on the water. Looking through the 20x scope, we counted 45 Snow Geese and 24 Ross' Geese in company with 11 Canada Geese and 115 White-fronted Geese. Dr. Millar pointed out the smaller size of the Ross' Goose as compared to the Snow Goose. I returned to the same place on September 15 and counted 15 Ross' Geese and six Snow Geese. Through the 20x scope, I could see that the Ross' Geese were only slightly larger than the Mallards which were with them. We saw small flocks of Ross' Geese almost every day until we left on September 20.—**George Chopping**, Dubuc, Sask.

EDITOR'S NOTE: Alex Dzubin, wildlife biologist with the Canadian Wildlife Service, reports that Ross' Goose has been a regular fall migra[illegible] slev are[illegible] have in[illegible] individua[illegible] ture. C[illegible] records [illegible] cent in [illegible] (1961 [illegible] miles from [illegible] we have [illegible] single R[illegible] nian, was [illegible] *from Sco*[illegible] [illegible] Regina.

INTER[illegible] BEHAV[illegible] HOUS[illegible]

This [illegible] prised [illegible] pleasin[illegible] and ra[illegible] observ[illegible] ford [illegible] either [illegible] from [illegible] mobile [illegible] this me[illegible] among [illegible] town [illegible] appea[illegible] consta[illegible] Vanco[illegible]

EDIT[illegible] attract[illegible] literature[illegible]

JS 1 - Janet js. 2th.
2 - Nancy ✓

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Bird Mortality at Four Towers in Eastern North Dakota--Fall 1972

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INTRODUCTION

During the fall of 1972, bird mortality was monitored at four towers in eastern North Dakota. The purpose of the studies was to determine how the nature of the mortality differed with the geographic location and other features of the towers. In this paper we report on the kinds and numbers of birds killed and discuss some possible factors involved. Previously, there have been many published reports of bird mortality at towers in other parts of the country (e.g., Brewer and Ellis, 1958; Stoddard and Norris, 1967, Laskey, 1969), but relatively few from the prairie pothole region of North America (e.g., Nero, 1961; Lahrman, 1965; Pierce, 1969). We believe this to be the first detailed account from North Dakota.

The study of investigations of bird migration and losses at the Omega Navigation Station was sponsored by the Northern Prairie Wildlife Research Center, Jamestown, North Dakota, through contract with the Department of Zoology, North Dakota State University. Data collected at other tower sites by North Dakota State University personnel are presented for comparative purposes.

DESCRIPTION OF TOWER SITES

Three of the towers (KXJB-TV, KTHI-TV, and WDAY-TV) are located in the east-central part of the state and hereafter are referred to as the east-central towers (Figure 1). The KXJB tower, 6.4 km (4 mi) east of Gales-

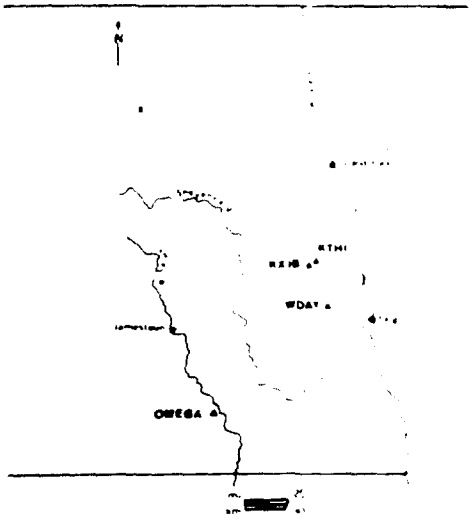

FIGURE 1. Location of tower sites

burg, and the KTHI tower, 4.8 km (3 mi) west of Blanchard, are separated by a straightline distance of 8 km (5 mi). Bare, plowed ground surrounded KXJB, while corn stubble fields surrounded KTHI. The towers are the two tallest in the world, 628 m (2060 ft) and 629 m (2063 ft), respectively, and each is supported by three sets of nine guy wires. At KXJB, the sets extend 435 m (1425 ft) from the base of the tower in northeasterly, southerly, and northwesterly directions, while at KTHI they extend 442 m (1450 ft) and are oriented easterly, southwesterly and northwesterly (Figure 2). Adjacent to each tower is a station building surrounded by a grassy area approximately 15 m (46 ft) in radius (0.07 ha, 0.17 acre). At KXJB, five-row shelterbelts border the northern and western edges of the site, approximately 450 m (1484 ft) from the tower. A one-row shelterbelt extends east-west approximately 500 m (1650 ft) north of the KTHI tower.

The WDAY tower, located 1.6 km (1 mi) east of Amenia, is 368 m (1206 ft) tall and is supported by three sets of six guy wires extending 305 m (1000 ft) in northerly, southeasterly and southwesterly directions (Figure 3). This

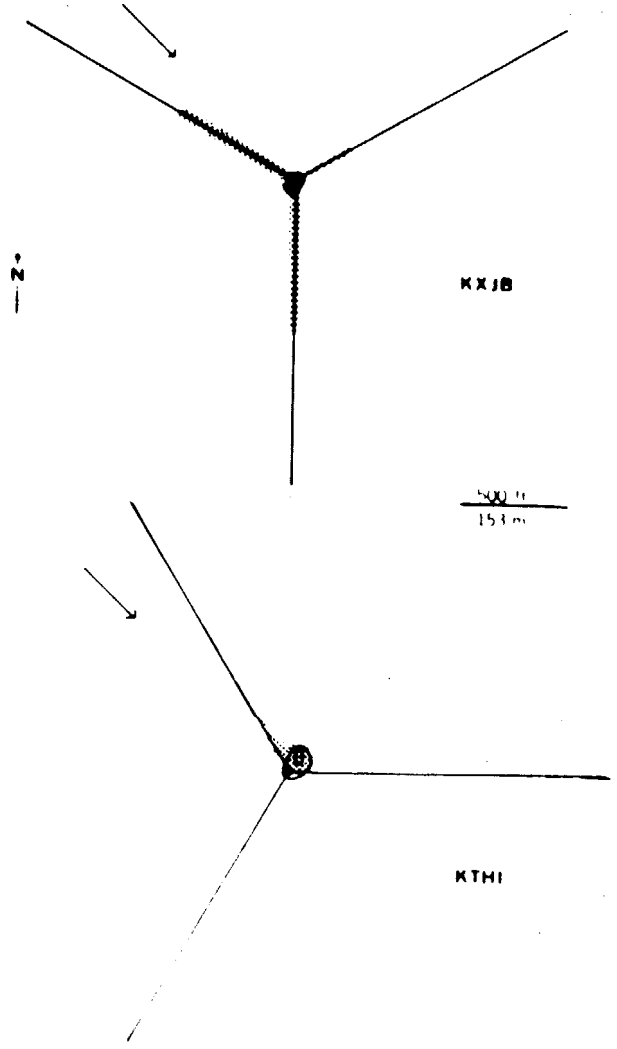

FIGURE 2. Location of the majority of the dead birds collected at the KXJB and KTHI towers (shaded areas). Arrows indicate principal direction of nocturnal migrants observed at the Omega tower.

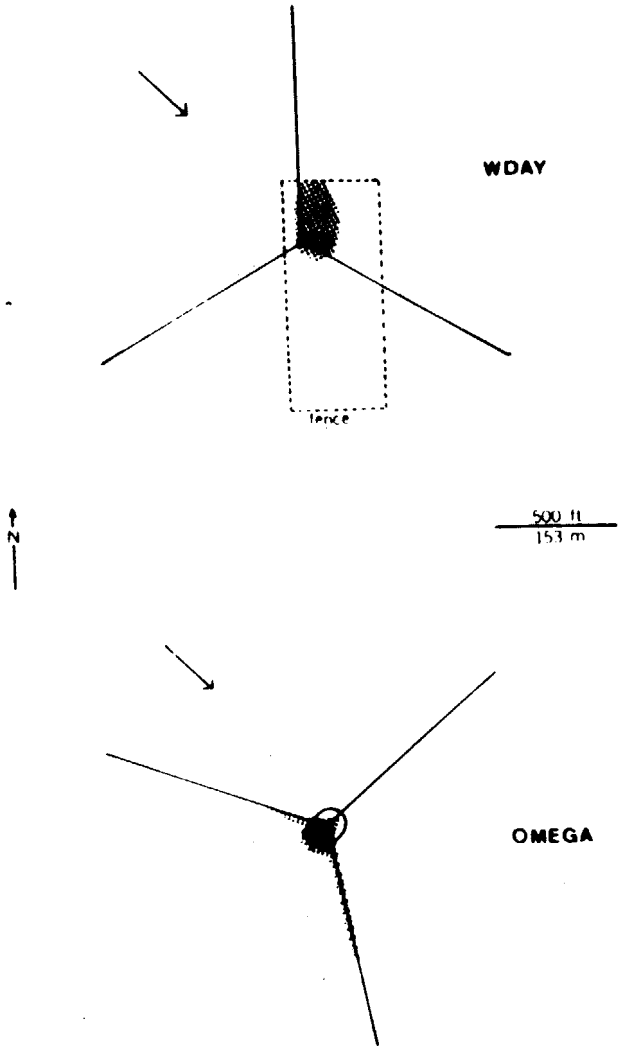

FIGURE 3. Location of the majority of the dead birds collected at the WDAY and Omega towers (shaded areas). Arrows indicate principal direction of nocturnal migrants observed at the Omega tower.

site was surrounded by stubble fields, but a 1.3 ha (3.2 acre) rectangular, mowed, grassy area surrounds the tower and station building.

The Omega tower is located in the James River Valley, 3.2 km (2 mi) west of the James River, in an area that varies from grassy uplands at the perimeter of the site to semi-permanent marsh by the tower itself. The tower is 366 m (1200 ft) tall and is supported by three sets of five guy wires extending 305 m (1000 ft) in northeasterly, southerly, and westerly directions (Figure 3). In addition, 16 evenly spaced transmitting cables extend from the top of the tower to a perimeter road 732 m (2400 ft) away. These cables form a part of the antenna system. A gravel area 46 m (150 ft) in radius (0.62 ha, 1.5 acre) surrounds the base of the tower and adjacent building, and three service roads radiate 312 m (1025 ft) into the marsh under the three sets of supporting guy wires.

All four of the towers are lighted in the conventional fashion with red, non-flashing, obstruction lights and red, flashing beacons. The KXJB and KTHI towers each have seven obstruction lights and seven beacons. On both towers, the obstruction lights and beacons are positioned alternately at intervals of approximately 45 m (148 ft). The WDAY and Omega towers are each equipped with five obstruction lights and four beacons. On the Omega tower, the obstruction lights are located at heights of 36 m (117 ft), 123 m (403 ft), 207 m (680 ft), 285 m (935 ft), and 326 m (1070 ft) and the beacons at heights of 86 m (281 ft), 168 m (551 ft), 243 m (798 ft), and 362 m (1187 ft). The lights at WDAY are located similarly.

Methods

The east-central towers were searched for dead birds on 24 August, 8 and 15 September, and twice a week thereafter through October. At KXJB and KTHI, a path approximately 6 m (20 ft) under each set of guy wires was checked to a distance of 305 m (1000 ft) from the tower. In addition, the roof and the small grassy area around each station building were searched. At WDAY, the entire mowed, grassy area and the roof of the station building were checked.

The Omega tower was searched daily from 8 August through 15 November. Since the dense marshy and grass vegetation made it impossible to search the entire area under the guy wires, a sampling plan was developed to obtain an estimate of the total kill (Avery *et al.* 1973). The central gravel area and the service roads were searched completely, and, in addition, 24 sampling plots, 12.2 m (40 ft) square, were located randomly throughout the marsh and grassy upland surrounding the tower.

Since the method of search precluded the estimation of total kills at the east-central towers, comparisons in this paper are based only on the birds actually found. No direct comparisons can be made of the total numbers collected since the Omega tower was searched daily and the east-central towers only twice a week. However, more valid comparisons can be made of the species composition and seasonal timing of the birds found at the various towers.

The senior author conducted all the searches at the Omega tower, and at the east-central towers on 24 August and 8 September. The junior author conducted the rest of the searches at the east-central towers.

Results and Discussion

A total of 561 birds of 88 species were collected at the four towers through mid-fall (Table 1). In addition, five red bats, *Lasiurus borealis*, were found, four at the Omega tower and one at KTHI. Based on the sampling plan, the

TABLE 1. BIRD LOSSES AT TOWERS IN EASTERN NORTH DAKOTA—FALL 1972.

Species	KXJB[1]	KTHI[1]	WDAY[1]	Total East-Central Towers[1]	Omega[2]	Grand Total
Lared Grebe (*Podiceps nigricollis*)					1	1
Pied-billed Grebe (*Podilymbus podiceps*)	1	1		2		2
American Bittern (*Botaurus lentiginosus*)					2	2
Mallard (*Anas platyrhynchos*)					1	1
Pintail (*Anas acuta*)					1	1
Green-winged Teal (*Anas crecca*)	1	2		3		3
Blue-winged Teal (*Anas discors*)					1	1
Northern Shoveler (*Anas clypeata*)					1	1
Lesser Scaup (*Aythya affinis*)					2	2
Ruddy Duck (*Oxyura jamaicensis*)					1	1
Marsh Hawk (*Circus cyaneus*)					1	1
Gray Partridge (*Perdix perdix*)		1		1		1
Virginia Rail (*Rallus limicola*)			2	2	2	2
Sora (*Porzana carolina*)	1					
Yellow Rail (*Coturnicops noveboracensis*)				3	12	15
American Coot (*Fulica americana*)	2	3	2	7	13	20
Common Snipe (*Capella gallinago*)					1	1
Mourning Dove (*Zenaidura macroura*)	2			2	1	3
Yellow-shafted Flicker (*Colaptes a. auratus*)	1	2	3	6		6
Yellow-bellied Flycatcher (*Empidonax flaviventris*)	3			3	1	4
Traill's Flycatcher (*Empidonax traillii-alnorum* complex)	1		1	2	2	4
Least Flycatcher (*Empidonax minimus*)	1			1	1	2
Tree Swallow (*Iridoprocne bicolor*)					2	2
House Wren (*Troglodytes aedon*)	3	1		4		4
Long-billed Marsh Wren (*Telmatodytes palustris*)	2		1	3		3
Short-billed Marsh Wren (*Cistothorus platensis*)	1			1		1
Gray Catbird (*Dumetella carolinensis*)		1		1		1
Robin (*Turdus migratorius*)			2	2		2
Wood Thrush (*Hylocichla mustelina*)		2	3	5	1	6
Hermit Thrush (*Catharus guttatus*)	5	3	1	9	4	13
Swainson's Thrush (*Catharus ustulatus*)						

TABLE 1 BIRD LOSSES AT TOWERS IN EASTERN NORTH DAKOTA — FALL 1972 (Continued)

Species	KXJB[1]	KTHI[1]	WDAY[1]	Total East-Central Towers[1]	Omega[2]	Grand Total
Gray-cheeked Thrush (*Catharus minimus*)			1	1	5	6
Veery (*Catharus fuscescens*)	1		1	2	1	3
Golden-crowned Kinglet (*Regulus satrapa*)	3	2		5	3	8
Ruby-crowned Kinglet (*Regulus calendula*)	1	1	4	6	3	9
Solitary Vireo (*Vireo solitarius*)			2	2		2
Red-eyed Vireo (*Vireo olivaceus*)	5	1	5	11	4	15
Philadelphia Vireo (*Vireo philadelphicus*)	1			1		1
Warbling Vireo (*Vireo gilvus*)	1		2	3	2	5
Black-and-white Warbler (*Mniotilta varia*)	4		2	6	3	9
Golden-winged Warbler (*Vermivora chrysoptera*)					1	1
Tennessee Warbler (*Vermivora peregrina*)	1		2	3	1	4
Orange-crowned Warbler (*Vermivora celata*)	2	1	4	7	9	16
Yellow Warbler (*Dendroica petechia*)	8	1	3	12	19	31
Magnolia Warbler (*Dendroica magnolia*)	2	1	1	4	1	5
Myrtle Warbler (*Dendroica c. coronata*)	4		1	5	13	18
Black-throated Green Warbler (*Dendroica virens*)					1	1
Blackburnian Warbler (*Dendroica fusca*)	1			1		1
Chestnut-sided Warbler (*Dendroica pensylvanica*)	2			2		2
Bay-breasted Warbler (*Dendroica castanea*)					2	2
Blackpoll Warbler (*Dendroica striata*)	1		1	2	2	4
Pine Warbler (*Dendroica pinus*)	1			1		1
Palm Warbler (*Dendroica palmarum*)			1	1	9	10
Ovenbird (*Seiurus aurocapillus*)	16	2	8	26	6	32
Northern Waterthrush (*Seiurus noveboracensis*)	3			3	2	5
Mourning Warbler (*Oporornis philadelphia*)	5			5	6	11
Common Yellowthroat (*Geothlypis trichas*)	3	2	1	6	8	14
Wilson's Warbler (*Wilsonia pusilla*)	5		1	6	4	10
Canada Warbler (*Wilsonia canadensis*)	1			1	1	2
American Redstart (*Setophaga ruticilla*)	1			1	2	3
House Sparrow (*Passer domesticus*)	1			1		1
Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*)					1	1

TABLE 1 BIRD LOSSES AT TOWERS IN EASTERN NORTH DAKOTA — FALL 1972. (Continued)

Species	KXJB[1]	KTHI[1]	WDAY[1]	Total East-Central Towers[1]	Omega[2]	Grand Total
Red-winged Blackbird (*Agelaius phoeniceus*)	1		2	3	1	4
Orchard Oriole (*Icterus spurius*)					1	1
Baltimore Oriole (*Icterus g. galbula*)	2	1		3	1	4
Rusty Blackbird (*Euphagus carolinus*)		1		1		1
Brown-headed Cowbird (*Molothrus ater*)			1	1	2	3
Rose-breasted Grosbeak (*Pheucticus ludovicianus*)	1		1	2		2
Purple Finch (*Carpodacus purpureus*)			1	1		1
Pine Siskin (*Spinus pinus*)			1	1		1
Savannah Sparrow (*Passerculus sandwichensis*)					10	10
Grasshopper Sparrow (*Ammodramus savannarum*)					3	3
LeConte's Sparrow (*Ammospiza leconteii*)	2		2	4	3	7
Sharp-tailed Sparrow (*Ammospiza caudacuta*)					1	1
Vesper Sparrow (*Pooecetes gramineus*)	1			1	2	3
Lark Sparrow (*Chondestes grammacus*)			1	1		1
Slate-colored Junco (*Junco h. hyemalis*)	24	12	6	42	4	46
Tree Sparrow (*Spizella arborea*)	7	29	3	39	7	46
Chipping Sparrow (*Spizella passerina*)					1	1
Clay-colored Sparrow (*Spizella pallida*)	1		1	2	7	9
Harris' Sparrow (*Zonotrichia querula*)	2	3		5	3	8
White-throated Sparrow (*Zonotrichia albicollis*)	2	1		3	3	6
Fox Sparrow (*Passerella iliaca*)	2	1	1	4	1	5
Lincoln's Sparrow (*Melospiza lincolnii*)			3	10	4	14
Swamp Sparrow (*Melospiza georgiana*)		1	4	5	3	8
Song Sparrow (*Melospiza melodia*)	1	1		2	2	4
Lapland Longspur (*Calcarius lapponicus*)		4		4	5	9
Smith's Longspur (*Calcarius pictus*)					1	1
Unidentified	13	1	8	22	2	24
Total (88 species)	163	82	90	335	226	561

[1] Generally searched twice a week (see Methods)
[2] Searched daily

total estimated kill at the Omega tower was 1037 birds. The greater number of birds actually found at this tower than at the other three was undoubtedly due in part to more frequent searches; however, the umbrella arrangement of the 16 transmitting cables, peculiar only to this tower, was probably an important factor.

In view of their similar locations and heights, it is remarkable that the kill totals of KXJB and KTHI were so disparate. Dead birds found at KXJB were virtually twice that at KTHI, and on 24 August, when 58 dead birds were collected at KXJB, only 1 was found at KTHI. The presence of the thick shelterbelts to the north and west of KXJB may explain some of this difference. Such habitat might result in larger numbers of low-flying or descending migrants being attracted to the vicinity of the KXJB tower than to the KTHI tower which has only a one-row shelterbelt nearby. Another major difference in the two towers is the orientation of the sets of guy wires. If we assume similar volumes and directions of migration past both towers, the difference in orientation of the guy wire sets at the two towers may account for the difference in the kill totals. Guy wires oriented as those at KXJB may be more likely to intercept southeast-moving migrants than those at KTHI (Figure 2). The orientation of the three sets of supporting guy wires at the Omega tower is very similar to that at KXJB, and at both of these towers the majority of the dead birds found were within 46 m (150 ft) of the tower base, beneath and in the area between the northwestern and southern guy wire sets. At WDAY and KTHI most of the dead birds were found northeast of the towers within 25 m (82 ft) of the structures (Figures 2 and 3). Certainly, both local habitat and orientation of guy wires merit further consideration as factors in bird mortality at towers.

The largest losses at the Omega tower occurred during the nights of 21-22 August (23 birds collected), 6-7 September (18 birds), and 4-5 October (48 birds). A cold front had passed through the area on each of the above days, and the nights were characterized by overcast skies and northerly winds. Numbers of birds picked up at the east-central towers on these occasions were 76, 20 and 27 respectively. Of the 27 birds found on 5 October at the east-central towers, 20 were from WDAY, the largest single collection of the fall for that tower. Unfortunately, a heavy rain rendered the areas around KXJB and KTHI excessively muddy, permitting only cursory searches. Otherwise, the total count for that day probably would have been greater.

Other large kills included 80 birds, mostly Slate-colored Juncos, collected on 12 October at the east-central towers, and 33 birds, mostly Tree Sparrows, on 3 November at KTHI, which had been picked up by station personnel (KXJB and WDAY were not checked). Cold fronts passing through the region on 10 October and 2 November likely were major factors in these two kills also. Interestingly, one and zero birds, respectively, were found at the Omega tower on the latter two occasions although overcast conditions prevailed there too. Possibly, this indicates that larger migratory movements occurred through the Red River Valley region than through the James River Valley on these nights.

Table 2 shows that the composition of the five principal species killed at the east-central and Omega towers was dissimilar. Species most frequently killed at the Omega tower, with the exception of the Myrtle Warbler, are characteristic of marsh, prairie grassland and brushy thicket areas, whereas those from the east-central towers prefer forest, forest-edge and brushy thickets.

This may reflect a difference in the general patterns of fall migration through the two regions, although local factors, including weather conditions and habitat, possibly contributed to the dissimilarities. Only the Yellow Warbler was common to both lists.

TABLE 2. MOST FREQUENTLY KILLED SPECIES AT THE EAST-CENTRAL AND OMEGA TOWERS.

East-Central Towers		Omega Tower	
Species	Number Killed	Species	Number Killed
Slate-colored Junco	42	Yellow Warbler	19
Tree Sparrow	39	American Coot	13
Ovenbird	26	Myrtle Warbelr	13
Yellow Warbler	12	Sora	12
Red-eyed Vireo	11	Savannah Sparrow	10
Total (39% of total kill)	130	Total (34% of total kill)	67

Scavenger and predator activity was noted at all towers throughout the study. While observations of marked birds placed at various sites around the Omega tower indicated that the daily, early morning searches kept losses of tower-killed birds there at a level of less than 5 percent (Avery *et al.*, 1973), such losses at the east-central towers probably were more substantial since searches were not made daily. There was no means to estimate the magnitude of the losses at the east-central towers, however.

SUMMARY

In the fall of 1972, bird mortality was monitored at the KXJB-TV, KTHI-TV, WDAY-TV and Omega towers in eastern North Dakota. Altogether, 561 birds representing 88 species were collected. Species most frequently killed at the east-central towers (KXJB, KTHI, and WDAY) were dissimilar to those most commonly killed at the Omega tower. Largest losses occurred on overcast nights following the passage of cold fronts through the regions. Scavengers and predators probably removed substantial numbers of tower-killed birds at the east-central towers.

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A Review of Factors Involved in Bird-Tower Kills, and Mitigative Procedures [1]

Bernard N. Jaroslow[2]

Between 5 million and 80 million birds are killed annually from collisions with man-made structures, with the largest kills occurring to passerine species on overcast nights during fall migration. An understanding of avian physiological and behavioral factors conducive to collision helps in development of methods for mitigation. Mitigating factors involve structure siting, light-source type and frequency of the signal, and precautionary measures for overcast weather and bird migration seasons.

INTRODUCTION - THE PROBLEM

Records of bird kills from collisions with man-made structures were made before the turn of the century. Lighthouse keepers early recognized the positive correlation between foul weather and the number of birds killed. They also recognized that the beacon light served as an attractant for birds in overcast weather, and attempted to mitigate the attraction by using colored filters and varying the flashing rates (Avery et al., 1978).

According to Banks (1979), an estimated 1.25 million birds are killed each year from collisions with towers, tall buildings, monuments and lighthouses, and 3.5 million die from collision with windows (Banks, 1976). According to the newsletter "Ecology USA" (May 7, 1979), this total is closer to 80 million birds.

One of the more thorough investigations of the problem of bird collisions is an 11-year study conducted at a TV tower in Leon County, Florida (Stoddard and Norris, 1967).[3] The largest single-night kill was estimated as between 4000 and 7000 birds in October 1955, with a 2500-bird kill recorded in October 1957. Over the 11-year period, about 30,000 carcasses were examined, although the number actually killed is probably several-fold higher because many birds were not found in the weeds or had been taken by scavengers.

The nightly toll during migration is highly variable. In 12 nights of bird collection at a TV tower in Topeka, Kansas, in the fall of 1954, the nightly kills ranged from 3 to 585, with a median of 25 (Tordoff and Mengel, 1956).[3] Finches and warblers composed about 70% of the victims; ovenbirds, vireos and thrushes made up another 25%. These proportions vary from one report to another, but the groups listed are consistently the major victims of bird-kills by collision. Hassler et al. (1963), using radar, found that some birds elected to fly under the overcast and others flew above. This is likely to be species- or group-specific behavior which might account for the preponderance of passerine birds that are victims of collision with towers and skyscrapers.

The most spectacular bird-kills have been the kill estimated at 15,000 to 30,000 birds at a 1000-foot TV tower, on the night of September 18, 1953, near Eau Claire, Wisconsin (Kemper, 1964), and the kill estimated at 50,000 birds at a ceilometer on the Warner Robins Air Force Base near Macon, Georgia, on the night of October 7-8, 1954 (Johnston and Haines, 1957).

Given this problem, the objectives of this paper will be to examine: 1) the conditions that lead to bird kills via collisions;

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[3]These studies are typical of the findings reported by many others. Avery et al. (1978) have published an excellent annotated bibliography which is concerned with the types and numbers of birds killed at principal sources of impact, e.g., TV towers, lighthouses, monuments, and around ceilometers.

2) the physiological and behavioral factors conducive to such collisions; and 3) some successful and proposed mitigative procedures.

CONDITIONS THAT LEAD TO BIRD-KILLS WITH STRUCTURES

Three major factors that lead to bird collisions with stationary objects are:

- "Invisibility" of the Object--A raptor in pursuit of prey, and waterbirds taking off in panic, may collide with transmission lines; low-flying nocturnal migrants often collide with tall, unilluminated structures such as buildings, stacks, and towers.
- Deception--The bird sees a continuation of air space beyond a reflecting window and strikes it at full flying speed.
- Confusion--Discrete sources of light attract, confuse, and disorient night migrators on overcast nights (for example TV towers or lighthouses).

Analysis

Invisibility

When birds strike wires, it is probably because the object has become "invisible" owing to inattentiveness of the bird. A falcon pursuing a pigeon or a flock of ducks taking off in panic may be too intent upon what it is doing, and, consequently, does not see wires. In transmission line corridors carrying more than one powerline, e.g., a 345-kV and a 765-kV system in the same corridor, the wires provide a formidable obstacle course for a panic-stricken flock of birds.

Transparent walls (windows) or glass-walled corridors which provide a view of an open outdoor space have been a source of constant, low-level kills of resident and migrating birds (Banks, 1976).

Birds flying at night may not see a structure in their flight path. The occasional large bird-kills that take place on clear nights during migration (Taylor and Anderson, 1973) may, conceivably, occur when an atmospheric temperature inversion with a low-level jet stream (<2000 ft. altitude) develops (Taylor, 1954). The migrating birds may descend to take advantage of the tail wind and large numbers collide with obstacles projecting into their air space (Hassler et al., 1963).

Deception

Birds that fly into windows are deceived by the reflections. A straight-on view reflects the clear flight path that the bird is using; from an angle, some other clear path may appear. This type of problem could occur either by day or by night.

Confusion

The most dramatic bird kills recorded are probably those that result from confusion. They occur when the sky is overcast (with and without rain, drizzle, or fog) and when light sources are present to attract the migrating birds. The light appears to serve as an attractive super stimulus in the absence of light from celestial objects.

Cochran and Graber (1958) graphically described how the area around a TV tower was occupied by a heavy concentration of birds circling around, and fluttering about in confusion. They suggested that the illuminated area around the TV tower served as a lighted room which many birds were reluctant to leave. Birds repeatedly circled the tower until they collided with guy wires or the tower frame, or finally fell exhausted to the ground. The behavior of the birds, and the numbers killed, were unaffected by whether the tower was or was not transmitting.

BEHAVIORAL FACTORS

There are several questions that must be answered before we can understand why the birds are killed in such large numbers and before we can develop methods for mitigating the magnitude of the problem. First, why are the birds attracted to the lights on overcast nights? Second, why do they fly around the lights until they are exhausted? Third, why do they seem to be so disoriented that they fly into the ground or into large, illuminated structures such as monuments and cooling towers?

To answer the first question we might examine the method by which birds navigate at night. The explanation for the large tower kills on overcast nights probably does not reside with a single behavioral response associated with migration; instead, it is the result of the relative strengths of different behavioral patterns at different stages of the migration.

It is now generally accepted that long-distance migrants primarily use celestial

navigation (Emlen, 1975). The first phase of setting out on a migratory flight is to determine the direction of the goal. According to the experimental data of Wiltschko and Wiltschko (1976, 1978), the initial orientation is determined from the geomagnetic field. The birds then take a bearing on the stars and use celestial navigation during the actual flight. The ability to navigate by the sun and stars during migratory flight includes the ability to compensate for the movement of the stars during the night (Emlen, 1975; Sauer, 1958).

I propose that, under overcast skies, the dominant orienting stimulus of celestial objects is lost; then, the dominant stimulus becomes the geomagnetic field. Leask (1977) suggests that the signal is associated with the optic apparatus and that the weak radiation of the geomagnetic field is amplified by a mechanism in the eye which is capable of "optical pumping." Whatever the mechanism is for sensing the geomagnetic field, the strength of this stimulus appears to be weak. The geomagnetic orientation may be maintained and strengthened by "consensus" of the flock, i.e., Graber (1968) reports "... migrants flying under complete overcast were extremely vociferous. As the cloud layer broke, calling declined, but as the overcast closed again about 2200 CST, calling began to increase again ...."

In any case, the strength of the orienting stimuli, in some night-migrating birds, is less than the stimulus produced by a point source of light when the sky is overcast. Kemper (1964) suggests that birds flying under overcast conditions orient on tower lights as they would on stars. As they approach the light their direction of flight relative to the tower light changes, and they are no longer in conformance with the celestial orientation established at or before take off. To make navigation corrections on what has become their "guiding star," the birds begin a spiral around the light. This terminates in collision with the tower or its guy wires, or with exhaustion and collapse on the ground.

Sometimes the point source of light is a ceilometer or an illuminated structure. When the birds enter the illuminated area, they appear to be confused and circle inside and around the illuminated area until they fly into a nearby structure or fall exhausted to the ground (Howell et al., 1954; Johnston and Haines, 1957) while in the beam of a ceilometer; and there is a report of many birds, on a rainy night, flying into the ground around a recreation area that was illuminated with tall light poles (James, 1956).

Herbert (1969) gives a convincing argument in explanation of the confusion and disorientation of birds when they fly into an illuminated area, particularly in rainy or misty conditions. He suggests that, in night flights, the birds stabilize themselves on a horizontal horizon, with lighter areas above and darker masses below the horizon. In the illuminated areas of a light source, they become disoriented and may suffer vertigo when their sense of gravity is at variance with their sense of vision. As a result, birds in the light beam are seen to flutter in a confused manner. Some of the birds are apparently so visually confused that in these situations they appear to accept the edge of light and darkness as the horizontal horizon, and fly into the ground; other birds refuse to leave the cone of light, flying round and round until they fall to the ground exhausted (Cochran and Graber, 1958; Howell et al., 1954; James, 1956; Johnston and Haines, 1957). In his discussion, Herbert points out that pilots have shown the same disorientation when confronted by bright lights on dark nights.

MITIGATION

Collisions resulting from "invisibility" of an object involve wires (e.g., transmission lines, telephone wires), transparent walls (glass-walled corridors between buildings), and tall structures not visible on dark nights.

Mitigation of kills by overhead wires and cables could be accomplished by conscientiously avoiding, where possible, the stringing of wires across flight corridors, for example, near lakes and ponds used by water birds, or across major migration corridors such as the Mississippi flyways (Goddard and Richardson, 1974). Silhouettes of raptors on windows have been used with success to reduce bird losses from collision with windows or window walls (National Wildlife, 1976). Tall, dark structures could be illuminated on clear nights but left darkened on overcast nights, when they would serve as an attraction and hazard.

Collisions resulting from deception occur when birds see a reflection of open air space and fly into the reflective surface, a frequent problem with modern architecture, which uses large areas of glass. In many instances, reflectivity is enhanced because the windows are covered with heat reflectors which can serve effectively as mirrors. This hazard primarily affects diurnal residents and migrants.

Mitigative procedures are several, but the easiest way to decrease the fidelity of the reflected image is to have white-lined drapes

in the room, or have the room lights on in the daytime whenever bird-strikes are likely to become frequent. Any method that would decrease the fidelity or the brightness of the reflected image would be helpful.

Collisions resulting from disorientation, with subsequent confusion, are associated with night migration on overcast nights. The disorientation results from stationary lights on the ground or on towers.

The study by Cochran and Graber (1958) provides information useful in understanding the causes of disorientation and in developing mitigative procedures to decrease collisions. By counting the number of bird calls per minute, they found that the numbers were much higher when the lights were on and decreased rapidly as soon as the lights were extinguished. They used different on/off sequences for tower lights and found that the number of bird calls increased about two minutes after lights were switched on, and by four minutes after illumination the frequency was at or close to maximum. Immediately after the lights were extinguished, the birds left the vicinity of the tower, as evidenced by the diminishing volume, as well as number, of bird calls. In support of the mitigative efficacy of intermittent illumination on the size of bird kills is a reference to an experiment at Dungeness Lighthouse in which the newly installed lighthouse beacon was flashed for one second in every ten-second period (Avery et al., 1976, citing Baldwin, Ontario Naturalist 3:3-11, 1965), and the numbers of birds killed declined from previous years when the illumination had been constant.

Mitigative procedures for aircraft warning lights on towers and tall structures should provide for a lighting sequence in which the lights are on for no more than two minutes and off for less than one minute on overcast nights during the migration season. Further research might show that a ten-second cycle, such as used at the Dungeness Lighthouse, is both feasible and effective. The light intensity should be decreased as much as is compatible with its function as a warning light. This would limit the zone of attraction and the intensity of the stimulus.

Illumination of tall structures such as monuments and cooling towers (Rybak et al., 1973), when used for esthetic purposes, should be stopped during the danger period. The lights in skyscrapers should be extinguished, if possible, or drapes should be drawn at those times.

Many experiments have been conducted to determine cause-effect relationships between different colored lights and bird collisions with illuminated structures, but the results are inconclusive.[4] This is not surprising. Studies of color vision in birds (review by Stillman, 1973) show that color sensitivity is highly variable among different families. Most unfortunately, few of these studies were concerned with passerines, due, in part, to the difficult technical problems in working with these small birds. A thorough study (Donner, 1953) of spectral sensitivity in pigeons showed that they have good vision over the entire region that humans call "visible light."

Ceilometers, because of their intense beam, provide a super stimulus, and attract migrators from many miles. Fortunately, mitigation of the problem is simple - use of ultraviolet light (Terres, 1956; Tordoff and Mengel, 1956) or infrared light (Donner, 1953). Both are invisible to birds but easily detected with instruments. According to Mr. Donald Whitman, Chief of Data Acquisition, National Weather Service, Central Division (Personal Communication), all U.S. airports use rotating beam ceilometers with continuous recording. Rotating beam ceilometers give light in the infrared range. (For example, the light source advertised by Weathertronics, Inc., is described as a laser diode that emits 400 W, peak power, at 900 nm.) A fixed-beam ceiling light is sometimes used with a five-minute on-off cycle. I am unaware of any bird-kills associated with the use of either system.

SUMMARY

Between 5 million (Banks, 1979) and 80 million (Ecology USA, 1979) birds are killed annually by collision with man-made structures. They collide with objects that are poorly visible, such as wires strung across their flight path; objects that deceive by reflecting a free flight path; or, on overcast nights, structures with point sources of illumination which act as super stimuli that attract, disorient, and confuse.

Mitigation can be achieved by better siting of wires, decreasing the reflectivity of surfaces, substituting ultraviolet or infared light in ceilometers, and using an appropriate on-off cycle for warning lights and ceilometers on overcast nights during migration (further research is required to determine the optimum cycle). Illumination for

[4] See the annotated bibliography of Avery et al. (1978) for references to these studies.

esthetic or advertising purposes should be extinguished, whenever possible, during danger periods.

ACKNOWLEDGMENTS

I wish to thank Ms. P. Merry, Dr. L. Soholt, and Dr. E. Pentecost of Argonne National Laboratory for their helpful contributions and discussions during the preparation of this manuscript. I am grateful to the Nuclear Regulatory Commission and the Department of Energy for support.

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species is presented in Table 2. he Shoveler (38), Ruddy Duck (26), Lesser Scaup (26), and of a species recorded on a single n 25 September.

LNTS

of the Department of Biology, e manuscript.

recorded from the sewage ponds ldsquaw (*Clangula hyemalis*) was until 30 November 1969. There he state. Two male White-winged on these ponds from 2 November ter (*Oidemia nigra*) was also ob- observed from 28 October until ecord for this species (D. James, ientation of extraordinary sight uglas James at the University of the state. This species was first of the Northeast Arkansas Audu- is record. Species of Scoter ducks al areas. There are very few rec- as (D. James, *Proc. Ark. Acad.* ords of the White-winged Scoter,

ity, Arkansas 72467.

AUTUMN 1969 T. V. TOWER CASUALTIES AT NASHVILLE

By Amelia R. Laskey

The collection of T. V. Tower casualties in autumn 1969 in Nashville was well organized under the leadership of M. L. Bierly, starting in late August and continuing until mid-November with the help of several others. The birds were brought to me, counted, listed and then frozen for future studies.

The first casualty was a Kentucky Warbler on 22 Aug. The total number killed was 1,909 of 70 species—307 (51 species) at WSIX and 1,602 (57 species) at WSM.

Excepting a Starling on 7 Sept. and an American Redstart on 10 Sept., no birds were found until 18 Sept. when 62 were gathered at the two towers and on 19 Sept. a total of 200. Northerly winds, subnormal mean temperatures, overcast skies and a passing cold front prevailed at this period.

The largest kill occurred on the night of 14-15 Oct. during a similar weather period. On that night there were 139 casualties at WSIX and 1,172 at WSM. After a telephone call at 21:30 14 Oct. from Mr. Clark Sewell, on night duty at WSM, M. L. Bierly, John Riggins, K. A. Goodpasture and A. R. Laskey collected 152 birds as they fell before midnight where they could be seen on the lighted concrete parking place southeast of the tower. The others were gathered from the grass and wooded area on the morning of 15 Oct. Among them were 254 Tennessee Warblers, 220 Ovenbirds, 206 Bay-breasted Warblers, 162 Magnolia Warblers and 115 Chestnut-sided Warblers.

In late October there were few casualties and from 1 Nov. through 12 Nov., only 27 at both towers. From 12 Nov. to the termination of the visits on 16 Nov., none was found.

Compared with previous records for early fall arrival and late departure of migrants, the following are of note: Golden-winged Warbler, 15 Oct.; Cape May Warbler, 14 Oct.; Black-throated Blue Warbler, 19 Sept.; Blackpoll Warbler, 15 Oct. (7 found at the two towers); Hooded Warbler, 16 Oct. (one at each tower).

The list for the two towers follows with the first numeral indicating WSIX and the second number WSM. An asterisk (*) indicates that the species was found only at WSM.

Sora 2; Yellow-billed Cuckoo 3; Black-billed Cuckoo 1*; Whip-poor-will 1-2; Yellow-shafted Flicker 1*; Yellow-bellied Sapsucker 2-1; Great Crested Flycatcher 1; Yellow-bellied Flycatcher 1-1; Acadian Flycatcher 1-1; E. Wood Pewee 1-2; Red-breasted Nuthatch 1-2; Brown Creeper 1-2; Winter Wren 1; Long-billed Marsh Wren 1-3; Catbird 4-12; Brown Thrasher 1; Robin 2*; Wood Thrush 16; Hermit Thrush 1; Swainson's Thrush 13-5; Gray-cheeked Thrush 18-1; Golden-crowned Kinglet 4-13; Ruby-crowned Kinglet

-9; Starling 1*; White-eyed Vireo 1-4; Yellow-throated Vireo 2*; Solitary Vireo 1*; Red-eyed Vireo 8-53; Philadelphia Vireo 2-14; Black-and-white Warbler 6-38; Golden-winged Warbler 1*; Tennessee Warbler 32-351; Orange-crowned Warbler 1-4; Nashville Warbler 7; Parula Warbler 1; Magnolia Warbler 17-204; Cape May Warbler 1; Black-throated Blue Warbler 3*; Myrtle Warbler 9-5; Black-throated Green Warbler 11-66; Blackburnian Warbler 10-53; Yellow-throated Warbler 1*; Chestnut-sided Warbler 8-126; Bay-breasted Warbler 41-246; Blackpoll Warbler 2-8; Palm Warbler 10-13; Ovenbird 25-249; Northern Waterthrush 4-4; Kentucky Warbler 3*; Connecticut Warbler 1*; Yellowthroat 7-14; Yellow-breasted Chat 4*; Hooded Warbler 2-3; Canada Warbler 1*; American Redstart 9-14; Bobolink 15; Brown-headed Cowbird 1; Scarlet Tanager 1-3; Summer Tanager 1-3; Rose-breasted Grosbeak 7; Indigo Bunting 6-16; Dickcissel 1; Pine Siskin 1; Grasshopper Sparrow 1*; Slate-colored Junco 2; Field Sparrow 2-1; White-crowned Sparrow 1; White-throated Sparrow 1-2; Swamp Sparrow 4-3; Song Sparrow 2; Unidentifiable on account of condition 1-5.

Grateful acknowledgment for their help is extended to M. I. Bierly, C. W. Fentress, K. A. Goodpasture, J. D. Parrish, John Riggins, L. O. Trabue and the personnel of WSIX and WSM T. V. towers.

The following correction should be made for the 1968 report on autumn casualties: *Migrant*, 40:25, paragraph 3, line 3: delete 311 Blackpoll Warblers, substitute 319 Black-and-white Warblers.

1521 Graybar Lane, Nashville 37215.

NOTICE TO MEMBERSHIP

Dues for 1970 are now payable. Payment should be sent to the Treasurer, Kenneth H. Dubke, 3302 Navajo Drive, Chattanooga, Tennessee 37411, as soon as possible. Your cooperation will be appreciated.

EASTERN BLUE
AT AS

By Amelia R. Las

For the 1969 nesting season Neptune Community of Ashlan number of nest boxes to 70, pla of rural road. Regular weekly M. F. Herbert and A. R. Laskey brood fledged. The nestlings w eight females were trapped wh One of these was nesting in th the others were in boxes from they had been hatched.

Nest-building started in late the peak on 12 April when 45 n plete sets of six eggs; 14 had s yolkless egg was laid in a new year House Sparrows (*Passer* 1968. They were persistant a and eggs. There were two Caro Tufted Titmouse (*Parus bicolor*

Of the 70 available nest boxes Eggs laid, 708 (166 sets); eggs number laid); unsuccessful eggs successful eggs and young is disc tabulated. The heaviest loss is d nests were intact as typical in s

A puzzling feature was the l of eggs (91 eggs in 22 nests). bluebirds over the nest box, bu We know that cats killed some t ever, as we live 30 miles from make the necessary observations obvious procedure is to move failures (seven in each of two

During the heat of summe sunshine, were abandoned and period, young in the nests w box top with aluminum foil w boxes containing eggs may be nesting season.

Small numbers disappeared fledged young. These were Seven young were found dead on

GENERAL NOTES

Attraction of nocturnal migrants by lights on a television tower.—Allen (1880. *Bull. Nutt. Orn. Club*, 5:131–138) called attention to the fact that birds killed themselves by flying against the lights of lighthouses. Some of the lighthouses at which bird mortality occurred had red lights, others white, some had flashing, and some had fixed lights. Gastman (1886. *Amer. Nat.*, 20:981) estimated that a thousand birds (fall migrants) were killed at electric light towers in Decatur, Illinois.

More recently, Pough (1948. *Audubon Mag.*, 50:354–355) described mass mortality of migrants on the Empire State Building, New York, but made no mention of lights on the building. Howell, Laskey, and Tanner (1954. *Wilson Bull.*, 66:207–209) indicated that migrating birds may be attracted by the light beam of airport ceilometers.

Mortality of nocturnal migrants at television towers has also received attention, and presently several studies of this phenomenon are in progress.

In their outstanding analysis of bird mortality at a 950-foot television tower in Topeka, Kansas, Tordoff and Mengel (1956. *Univ. Kans. Mus. Nat. Hist. Publ.*, 10:17–20) discussed, among other things, the randomness of the sample of birds killed and calculated the number of migrants, assuming that the birds were uniformly spaced across the sky and neither attracted to the tower nor dispersed by it.

Recently the present writers made observations at a 984-foot television tower located 10 miles west of Champaign, Illinois, and obtained evidence that nocturnal migrants may be attracted by the red lights which are placed at 140-foot intervals along the tower.

During the night of May 29–30, 1957, there was a notable migration of birds in the vicinity of Champaign County. One or the other of the writers was present at the television tower from 8:00 p.m., May 29 until 5:15 a.m., May 30. The area was overcast and a light mist fell during part of the night. The surface wind was light from the E.S.E. Graber did not arrive at the tower until 11:30 p.m., but heard birds passing over the city of Champaign between 10:00 and 11:00 p.m. and also at two places along the 10-mile route from city to tower when he stopped to check on the migration. Upon reaching the transmitter he was immediately impressed by the great number of bird calls heard in the vicinity of the tower. It was apparent that there were more birds near the tower than away from it.

Besides hearing the birds we found that we could see birds passing the tower through the beam of an automobile spotlight. The spotlight beam reached the top of the tower, and we could judge the height of passing birds by the positions of the red tower lights and the attachment points of three sets of cable guys. Table 1 summarizes counts of birds which we made between 1:24 and 5:03 a.m.

Throughout this period migrants were around the tower and from call notes we identified Veeries (*Hylocichla fuscescens*), Dickcissels (*Spiza americana*), and Indigo Buntings (*Passerina cyanea*). Many of the birds probably were warblers, but we could not be certain of their identity.

The migrants were not evenly distributed but appeared in waves from the south. In the vicinity of the tower they were obviously confused, and their behavior was similar to that described for birds in a ceilometer beam by Howell, Laskey, and Tanner (1954. *Wilson Bull.*, 66:209). The migrants flew quickly through the framework of the tower, then circled at the edge of the lighted area and passed through the tower again. Most birds flew between elevations of 400 and 900 feet, but a few were above the tower and some were as low as 150 feet. In spite of the numerous obstructions which the framework of the tower offered and the fact that as many as 51 birds passed through or near

the tower in one minute, very few st
failed to find specimens the followin
minute varied from 9 to 26. and
(Table 1). We could not tell how
entered the beam and the tower st

The spotlight beam itself may hav
birds behaved in the same confused
the spotlight was off we could see
tower lights, and it was apparent
directions. How long an individual
know, but from the call notes we fel
others were moving away to the nor

SUMMARY OF OBSERVATIONS
CHAMP

Time CDST a.m.	Minutes	Bird notes heard
1:24–1:32	8	70
1:55–2:00	5	
2:04–2:09	5	104
2:25–2:31	6	
2:33–2:37	4	102
2:40–2:44	4	102
2:45–2:49	4	
3:03–3:05	2	
3:20–3:24	4	102
3:25–3:30	5	
3:50–3:54	4	101
3:55–4:02		
4:22–4:29	7	101
4:30–4:40	10	
4:50–4:56	6	51
4:56–5:01	5	
5:03	Quite light but	

With the spotlight we could tra
usually lost them as they entered th
birds away from the tower. Two o
east, and all three gained altitude
birds as they left the tower frame

Because the television tran
observations began, we assumed
the lights.

Observations made between 3:30
this view. At this time the sky w
arrived at the tower (approximat
lights were on. We noticed a few
mitter building and identified
Warbler (*Dendroica coronata*)
other birds calling as they flew

...ision tower.—Allen (19...
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...ashing, and some had fixed ligh...
...a thousand birds (fall migrant...
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...0-foot intervals along the tower.
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...p.m., but heard birds passing over...
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Spiza americana), and Indigo Bun...
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Howell, Laskey, and Tanner (1951...
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...y as 51 birds passed through or near...

the tower in one minute, very few struck it. We heard several hit during the night but failed to find specimens the following morning. The number of birds heard to call per minute varied from 9 to 26, and the number seen per minute varied from 5 to 51 (Table 1). We could not tell how many times an individual bird was counted, for birds entered the beam and the tower structure from every possible direction.

The spotlight beam itself may have had some effect on the migrants, but certainly the birds behaved in the same confused manner whether the spotlight was on or off. When the spotlight was off we could see those migrants that passed very close to the red tower lights, and it was apparent that birds entered the lighted area from different directions. How long an individual bird may have flown about the tower we do not know, but from the call notes we felt certain that new birds were arriving regularly while others were moving away to the north or northwest.

TABLE 1
SUMMARY OF OBSERVATIONS MADE AT TELEVISION TOWER ON MAY 29, 1957, CHAMPAIGN COUNTY, ILLINOIS

Time CDST a.m.	Minutes	Bird notes heard	Birds heard per minute	Birds seen	Birds seen per minute	Elevation of most birds (feet)
1:24–1:32	8	70	9	78	10	600–900
1:55–2:00	5			106	21	400–600
2:04–2:09	5	104	21			
2:25–2:31	6			185	31	400–500
2:33–2:37	4	102	26			
2:40–2:44	4	102	26			
2:45–2:49	4			202	51	Under 500
3:03–3:05	2			33	17	
3:20–3:24	4	102	26			
3:25–3:30	5			155	31	400–600
3:50–3:54	4	101	25			
3:55–4:02	7			151	22	400–500
4:22–4:29	7	101	14			
4:30–4:40	10			101	10	400–500
4:50–4:56	6	51	9			
4:56–5:01	5			26	5	
5:03	Quite light but birds are still passing.					

With the spotlight we could track individual birds as they approached the tower, but usually lost them as they entered the tower framework. Three times we tracked individual birds away from the tower. Two of these flew to the west-northwest and one to the northeast, and all three gained altitude as they left the tower area. Several times we tracked birds as they left the tower framework and saw them circle and return to the tower.

Because the television transmitter itself was turned off (at 12:45 a.m.) before our observations began, we assumed that the confusion of migrants was caused solely by the lights.

Observations made between 3:30 a.m. and 5:45 a.m. on November 5, 1957 corroborated this view. At this time the sky was overcast, but there was no precipitation. When we arrived at the tower (approximately 3:30 a.m.) the transmitter was off, but the tower lights were on. We noticed a few birds fluttering about the outdoor lights of the transmitter building and identified five Slate-colored Juncos (*Junco hyemalis*) a Myrtle Warbler (*Dendroica coronata*), and a Swamp Sparrow (*Melospiza georgiana*). We heard other birds calling as they flew about the transmitter tower and counted eight call notes

per minute during a four-minute period. In quick succession, we then made call note counts of migrants as follows: one mile east of the tower at a place without lights—one bird heard in five minutes, two miles southeast of the tower—no birds heard in five minutes. Returning to the base of the tower, we continued making counts as follows: with tower lights on, 30 birds in four minutes; all lights off, no birds in four minutes; tower lights on, 9 birds heard, all near the end of a four-minute period; lights on, 7 birds in four minutes; lights on, 55 birds in four minutes; lights off, 6 birds heard, all in the first two minutes of a five-minute period; lights on, no birds in first two minutes, but after the lights had been on four minutes we heard 76 call notes in the next four minutes.

Turning off the tower lights definitely eliminated the congestion of migrants about the tower. Immediately after the lights went off, we could tell by the diminishing volume of call notes that birds were leaving the vicinity, and in less than two minutes all birds were out of hearing. After the tower was relighted it took from one to two minutes for the first birds to come into hearing, but thereafter the number of call notes increased dramatically.

We could not identify, with certainty, any of the migrants that we heard during the night, but at 7:15 a.m. we found five freshly killed birds (three Fox Sparrows, *Passerella iliaca*; one Golden-crowned Kinglet, *Regulus satrapa*; and one Woodcock, *Philohela minor*), and three crippled birds (two Slate-colored Juncos and one Golden-crowned Kinglet) under the east and west guys which support the tower.

Our observations indicate that confusion of nocturnal migrants by tower lights occurs only on nights when the ceiling is low, and migrants are apparently forced to fly near or below the 1000- to 3000-foot level. On clear nights or on nights when cloud cover is high, we learned, through the use of special audio equipment (unpublished manuscript) that numbers of high-flying migrants pass the vicinity of the tower without becoming confused.

Thus, calculations of total numbers of migrants based on the sample of birds killed at television towers are erroneous on at least two counts: (1) migrants are attracted to the towers by the tower lights, and (2) only a very small per cent of the birds which reach the tower are killed.—WILLIAM W. COCHRAN, *WCIA, Champaign, Illinois, and* RICHARD R. GRABER, *Illinois Natural History Survey, Urbana, Illinois, April 24, 1958.*

Early record for the Ivory-billed Woodpecker in Kentucky.—An early record from Kentucky seems to indicate a greater amount of wandering among Ivory-billed Woodpeckers (*Campephilus principalis*) than has commonly been attributed to them. Col. Wm. Fleming noted in his journal for March 7, 1780, while near St. Asaph's, or Logan's Fort, about 20 miles south-southeast of Harrodsburg, that he had met with a species of woodpecker new to him (N. D. Mereness, 1916, "Travels in the American colonies," pp. 632-633). He saw two individuals, "the Cock and the hen," the former having "a bright red head with remarkable large tuft of feathers on the Crown . . . the body and the wings White and black." One of the birds was shot, the female. Fleming thought (but probably a male of the previous year, according to Dr. James T. Tanner [letter to K. L. Dixon, June 25, 1958]). Fleming's description was essentially as follows: ". . . the feathers on the throat and belly and part of the wing and tail a shining black. it had nine stiff and strong feathers in the tail. . . , the middle one being six inches long from where the feathers begins. . . , its wings ten Inches long from the shoulder [*bend?*] to the tip, 18 long feathers in the wing, the two first and longest black[,] the 3rd tipd with white and each succeeding one more and more till the next to the body

are white, both above and below. th junction of the upper and lower bi black feathers from the Eyes and ba legs was an inch and a half long and four inches in length[.] the bi is three inches in length, the tongue bright Yellow. . . , it weighed upwa

Fleming evidently began counting most. Judging from Ridgway's meas 167, and pl. 8), the wing was larger not clear how the measurements were The bill length is only slightly too seems right.

Tanner (1942. *Nat. Audubon Soc.* identity or, at least, unproved, the c (*in* Bent. 1939. *U.S. Nat. Mus. Bull.* in Franklin and Monroe counties, I evidence, presumably from the 15th c Ohio (1943. *Wilson Bull.*, 55:55). Indiana reports, it does make them a

Editorial help from K. L. Dixon a thanks.—DANIEL MCKINLEY, *Biology August 7, 1958.*

Production of pellets by a Blue *cristata*), which was recovering from tree in our yard at Greenbelt, Prince U.S. National Museum, identified the

As soon as we placed the jay in t gleaned insects from the leaves and occasions, once on July 7, 1958, and hard pellet composed entirely of corn pellet's surface was a hard, rough s consisted of the reddish tips of the flo and had two slightly tapering ends.— *Missouri, August 26, 1958.*

Ruby-throated Hummingbird ca Conrad Steele of Lexington, Virginia, September, 1957, at Lexington, he saw mingbird. While he is not particularly bird (*Archilochus colubris*) is our or which were some flowers that hummin noise in a bush. Walking to the spot hummingbird's neck. When he clapp flew a short distance and fell to the it was a hummingbird. After resting apparently in good condition.—J. J. M *December 18, 1957.*

Tall Television Tower and Bird Migration

Max E. Pierce

THE construction of the 1,117-foot high television tower for KSOO-TV eight miles southeast of Flandreau, South Dakota was completed in July, 1960.

Scott Findley made us aware of migratory birds being killed by such tall structures through studies made at WEAU-TV, Eau Claire, Wisconsin and other parts of the country. Due to Scott's encouragement we kept a record of such occurrences at KSOO-TV, although somewhat incomplete at times.

Each year the tower was standing between July 1960 and May 1968 we recorded instances of birds being killed by striking the tower. However, with the exception of 1965 only one or two birds at a time were recorded, and only during fall migration. During spring migration except for one or two occasions, did we ever find a dead bird at the base of the tower.

On the night of March 27 and the early morning hours of March 28, 1965, some 578 horned larks were killed either by flying into the tower or the transmitter building. This was during a rather freakish storm containing much snow and high winds that came up suddenly and dissipated just as quickly. It is believed that most of these birds were killed by flying against the lighted windows of the transmitter building. The engineer on duty turned out all lights except those on the tower and one small light inside the building, then closed all window shades. These measures proved effective as afterwards, very few birds struck the windows. As soon as the storm was over, we recovered 578 individuals, all horned larks. This instance can hardly be considered as having occurred during spring migration, considering the time was late March and all individuals recovered were horned larks, and winter residents. We have never since noted a similar accident.

The worst instance of migratory birds being killed at the KSOO-TV tower occurred between 4:30 and 6:30 a.m. on the morning of September 14, 1965, when approximately 200 individuals were killed. One hundred and two birds of 32 different species were recovered. Unfortunately a large number were not recovered because their condition was such that positive indentification could not be made. A complete list of those recovered is given at the end of this report.

The weather just prior to the time the birds started hitting the tower and building was very unsettled. The temperature was in the 60's with very little wind. About 4:30 a.m. the engineer on duty first noticed the birds hitting the windows, and immediately turned out all lights with the exception of the tower lights and closed all window shades. The birds continued striking the windows and tower until about 6:30 a.m. Approximately 15 minutes later a violent thunderstorm broke with heavy driving rain and very strong northwest winds which continued for about one hour.

It is believed that a migration wave was flying ahead of the storm and because it was so close behind them, were flying at a lower altitude than normal. Again, as in the spring, we felt most of the birds were killed by striking the building.

The KSOO-TV engineering staff at the transmitter have instructions to recover as many birds as possible after instances of this kind in order to help determine what steps we can take, if any, to reduce the number of birds killed in this manner. Unfortunately we have as yet been unable to make any study of this nature at the new 2,000-foot TV tower.

We wish to thank Mr. Herbert Krause and Dr. Willard Rosine of Augustana College for their work in identifying the birds listed below. Also great credit must be given to J. Scott Findley for his aid, interest and encouragement in this study during the years and for his help in preparing this report.

LIST OF IDENTIFIED BIRDS KILLED SEPT. 14, 1965

Pied-billed Grebe	1
Least Bittern	1
Sora Rail	1
Mourning Dove	1
Wood Pewee	1
Short-billed Marsh Wren	1
Catbird	12
Swainson's Thrush	12
Gray-cheeked Thrush	5
Cedar Waxwing	1
Solitary Vireo	1
Red-eyed Vireo	5
Philadelphia Vireo	2
Black and White Warbler	3
Nashville Warbler	7
Parula Warbler	1
Yellow Warbler	2
Bay-breasted Warbler	1
Black-throated Blue Warbler	1
Blackpoll Warbler	2
Pine Warbler	1
Ovenbird	8
Northern Waterthrush	1
Mourning Warbler	5
Yellowthroat, male	5
Yellowthroat, females	10
Wilson's Warbler	3
Bobolink	1
Scarlet Tanager	1
Rose-breasted Grosbeak	1
Field Sparrow	1
Lincoln Sparrow	3
Swamp Sparrow	1

Totals: 32 species - 102 individuals

—Director of Engineering, KSOO-TV, Inc., Sioux Falls, S. Dak. 57102

Your Records Can Really Contribute

(Adapted from **Atlantic Naturalist**, Vol. 23:152)

PEOPLE tend to send in lists when they go to a known good birding spot, which is fine, but one of the great lacks in our records is of birds in your own garden, giving early and late dates, peak numbers, and nesting dates. We suspect that most members believe the study of field ornithology is far more advanced than is really the case. With every review of the **Field List** we realize how little we know about bird migrations, habits, and nesting, and the many other details that a broad range of observations from members could provide. We need a reliable corps of observers well distributed through our region who will send in their reports systematically, and to whom we can send seasonal suggestions.

Perhaps the traditional name of "check list" for the printed form we urge members to use is one stumbling block. May we suggest a rule: NEVER JUST CHECK A CHECKLIST. A compiler finds few things more frustrating than lists by good observers, from choice areas on ace migration dates, on which just a check mark appears after

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KENETECH Windpower

AVIAN RESEARCH PROGRAM

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PREFACE

Since the mid-1980s, KENETECH Windpower has been actively engaged in an effort to understand the extent and cause of avian mortalities on its electric-generating wind energy facilities. KENETECH has monitored wildlife behavior at its wind power plant, or Windplant™, in the Altamont Pass, east of San Francisco, California, on a pre- and post-construction basis. The company also contributes funds to the State of California for the purchase of off-site wildlife habitats; has developed a wildlife response and reporting system; and has funded a project to test painted turbine blades as a potential bird warning mechanism. To date, KENETECH has allocated and spent more than $1 million dollars on avian protection and related activities.

These efforts have evolved into a three-pronged action plan. The first element is the development and implementation of siting procedures designed to eliminate potential environmental conflicts. As part of the initial screening process leading to the selection of a site, KENETECH identifies and consults with local and regional experts and conducts an extensive review of existing environmental studies and state and federal inventories. With each successive stage of site qualification for potential development, the level of analysis of potential environmental impacts becomes more intensive.

The second element is mitigation. Recognizing that research-based modifications of existing and/or future Windplants may be limited, KENETECH Windpower continues to participate in programs that offset losses to wildlife. These programs involve plant and animal species which are either directly affected by wind energy development, or are under great stress in other regions due to other causes.

The third element is research-based modification of wind turbines and/or an entire Windplant energy system. This third course of action is the focus of this document.

In 1992, KENETECH Windpower established an Avian Research Task Force, comprised of nationally-reknown ornithologists and research biologists, to conduct extensive research on the interaction of birds with the wind turbines in KENETECH Windpower's Windplant in Altamont Pass, California. The findings of this research are intended to offer effective long-term mitigation measures designed to substantially reduce the threat to birds — particularly large birds of prey — which reside in, or migrate through, the Altamont Pass Wind Resource Area.

BACKGROUND

Birds both avoid and collide with obstacles either natural or man-made that occur along their paths of flight. It is estimated that *annually* birds are killed in 57 million collisions with vehicles; 1.25 million collisions with tall structures (towers, stacks, buildings); and more than 97.5 million collisions with plate glass.

Birds collide with wind turbines as well. Of particular concern is the loss of raptors (birds of prey) in the Altamont Pass wind energy production area near Livermore, California. A specific focus of public concern is the loss of Golden Eagles in this area.

In April of 1992, a two-year study of the Altamont Pass wind energy production area commissioned by the California Energy Commission (CEC) identified 43 bird carcasses (19 of which were raptors) which may have been killed by wind turbines within the study area (approximately 16 percent of the 80-square-mile wind energy production area). The consultants extrapolated this data and concluded that as many as 567 raptors may have died within the entire Altamont Pass wind energy production area (which contains more than 7,000 wind turbines) during the two-year study. The consultants also estimated that as many as 78 of these mortalities were Golden Eagles.

The CEC study projected that the number of raptor strikes per 100 turbines ranges from 2.3 to 5.8 annually. Separate studies at another site, commissioned by KENETECH Windpower, estimate that the range is 1.7 to 4.8 raptor strikes, per 100 turbines, per year.

These losses, in a statistical sense, are rare events. No observations of a bird flying into a wind turbine were made in the course of the CEC study or the studies commissioned by KENETECH. The number of mortalities recorded is so small that no statistically reliable conclusions can be drawn regarding location, conditions and activity/behavior of the birds at the time of death. Therefore, it is difficult to determine the specific circumstances under which collision deaths occur.

In fact, there have been only two documented sightings of a wild bird impacting a turbine in nearly fifteen years of wind energy production. Moreover, in its ongoing research program (described below), the Avian Research Task Force has released homing pigeons in over 5,000 flights in and around KENETECH's wind turbines yet only two pigeons have been observed colliding with a wind turbine.

This information is presented not to minimize the gravity of the problem but, rather, to demonstrate the need for a comprehensive research strategy which examines the circumstances surrounding bird collisions with turbines.

PROJECT OVERVIEW

KENETECH Windpower is the world's leading developer of wind energy systems. The company operates 350 MW Windplant™ in the Altamont Pass, east of San Francisco. On that site, more than 3,000 KENETECH Windpower wind turbines generate electricity under a long-term power contract with the local utility.

KENETECH believes that pollution-free wind generated electricity has outstanding ecological benefits—for the environment and for society. Inherent in this belief is KENETECH Windpower's commitment to safeguard the wildlife which is native to areas utilized for wind energy production.

For this reason, KENETECH Windpower has launched a multi-year research and mitigation development program in an effort to enhance the collision avoidance capabilities of avian species that utilize the open space and habitat located in, or around, the Altamont Pass wind energy production area.

This research program is examining the sensory discrimination skills of American Kestrels, Red-tailed Hawks and Golden Eagles to determine what visual and auditory stimuli are most effective in improving a bird's recognition of a wind turbine as an obstacle to be avoided. It is anticipated that it will take until the spring of 1994 to make these broad determinations.

Based on this research, potential visual and/or auditory stimuli will be installed on or near specific KENETECH Windpower turbines in the Altamont Pass, and the effectiveness of these devices will be monitored. The installation and monitoring of these devices is expected to begin in the 1994 "wind season" (April-October). The effectiveness of the adaptations will be assessed and additional avoidance technologies and strategies analyzed as they are developed.

On a parallel research track, avian behavior within the Windplant will be documented. In this research, selected KENETECH Windpower turbine arrays are being monitored by the Research Task Force. Recorded observations in the wind resource area are made of wild bird flight activity/behavior and of controlled flights of captive birds, under a variety of conditions and circumstances (to accelerate its research and to collect enough data to make valid findings, the Task Force is augmenting its observation of wild bird activity with trained homing pigeons—see below).

A three-dimensional (3-D) tracking system was developed specifically for this research by the scientists of the Task Force. The tracking device records the flight paths of a bird as it maneuvers along a string of wind turbines under a variety of conditions. The tracking device also calculates the point(s) at which birds "flare" or alter their flight path to avoid the turbine(s).

The recorded flight tracks will be analyzed by the Task Force to establish a baseline of flight behavior around turbines and to determine how flight behavior is affected by various conditions. The flight pattern data may also help the Task Force determine which area around wind turbines poses the greatest collision-risk to birds in flight — the zone in which a bird cannot alter its flight to avoid passing through the rotor sweep of the turbine. Then, this data will be used to assess the effectiveness of potential mitigation techniques and technologies.

It is anticipated that a reliable database regarding flight patterns and behavior will be accumulated by the Spring of 1994, in time for the assessment phase.

Research and observations of wild bird behavior will continue in an effort to document activity and behavior patterns which may provide clues to possible causes of avian collisions (especially those involving raptors) with wind turbines.

A study of the raptor population in the Altamont Pass — with an emphasis on Golden Eagles — is also under development. Funding assistance for this project is currently being solicited. Research is expected to begin in late 1993.